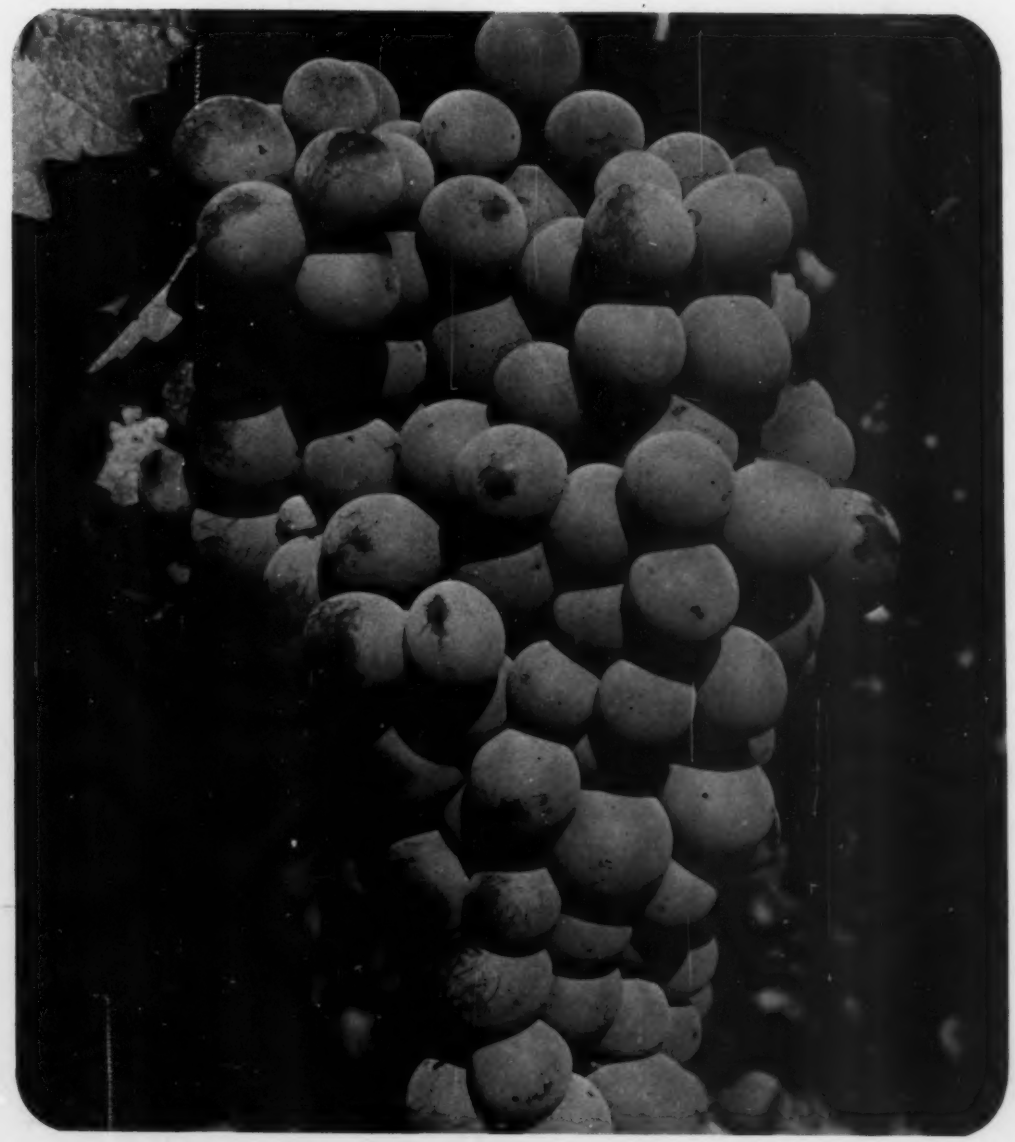
August 1972

RECLAMATION era

A WATER REVIEW QUARTERLY



August 1972 • Vol. 58, No. 3

RECLAMATION era

Kathleen Wood Loveless, Editor

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COVER. Succulent Emperor grapes is only one of many varieties nourished by water supplied by the Bureau of Reclamation. Read of the raisin-making variety on the next page.

United States Department of the Interior
Rogers C. B. Morton, Secretary

Bureau of Reclamation, Ellis L. Armstrong Commissioner

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COMMISSIONER'S PAGE

Project Skywater

For untold years man has sought to control life-giving rain and snow. And for almost as many years, he has progressed toward this goal. Only recently, however, have scientists had the tools to understand what goes on in the clouds. Most encouraging of all is the realization that limited control of weather is definitly within our capabilities.

It has been estimated that fifteen quadrillion gallons of water pass across the United States during an average year. Approximately 10 percent of this water falls naturally as precipitation. The water problem in the United States is not so much one of too little precipitation across the whole Nation, but that of a greatly disproportionate amount in individual areas.

Crops are destroyed—some by drought, some by floods; residential areas are hampered or ruined again by drought or flood; and wildlife and livestock are easy prey to the whims of weather.

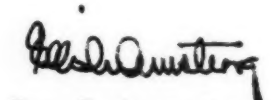
Since the Bureau was authorized by Congress in 1961 to conduct research on weather modification, it has been our purpose to mitigate the detrimental effects of uneven distribution of precipitation.

From the earliest days of Reclamation, our dams and reservoirs have served to control floods and thus eliminate the problems caused thereby, and at the same time save water for periods of low flow.

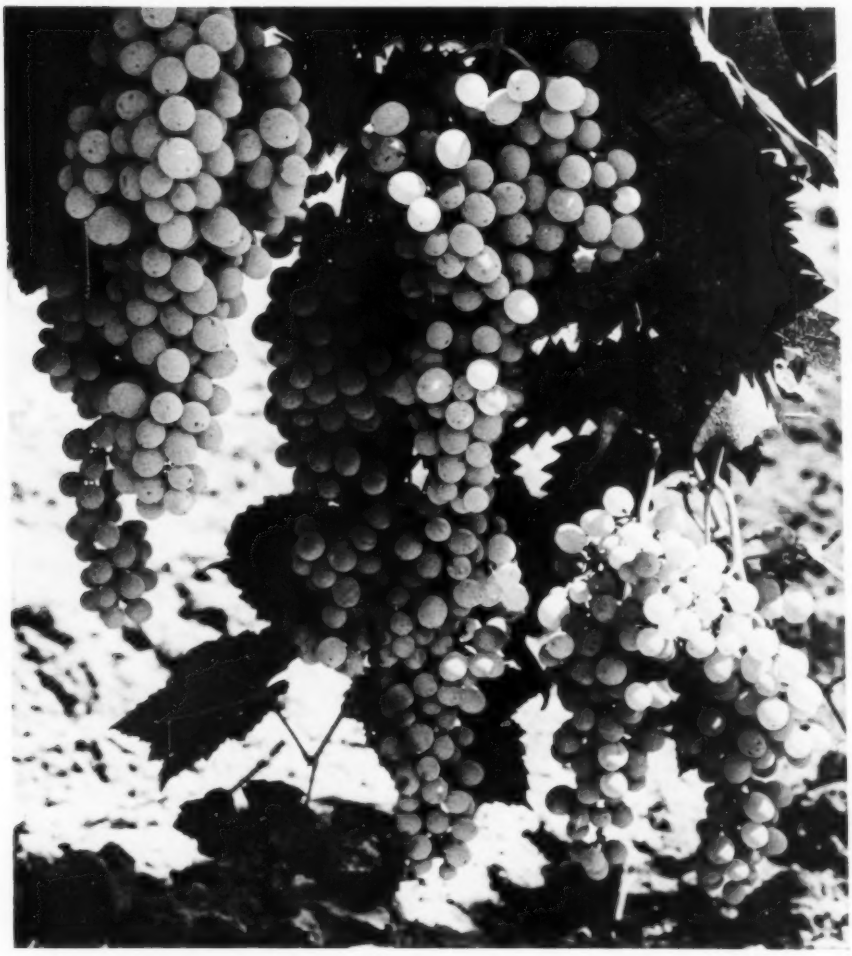
Now we also focus our attention on the other problem—periods of insufficient precipitation. This is the purpose of "Project Skywater"—research to determine how added moisture may be induced from the sky by cloud seeding.

The Colorado River Basin Pilot project is our most ambitious undertaking, designed to evaluate an operational winter-seeding program. The project area embraces 3,300 square miles in the San Juan Mountains of southwestern Colorado, including several mountain streams which contribute significant flows to the Colorado River. And now we also engage in summer-seeding research.

There is no doubt that, under certain conditions, cloud seeding can increase precipitation. The increases range from a few percent to several hundred percent. Hence, with continued research, cloud seeding may become a practical and widely-used method of augmenting precipitation.



ELLIS L. ARMSTRONG
Commissioner of Reclamation



Thompson seedless grapes in a vineyard near Fresno, Calif.

from GRAPES to RAISINS IN CALIFORNIA

Mechanical grape harvester in operation.

①

②

③

NOT many fruits are as delicious dried-up and lacking natural juices as are grapes. But then, grapes become raisins. The versatile grapes not only may grace your table as a sweet wine, but may garnish your morning cereal and cinnamon rolls, or even become eyes on a gingerbread man.

The transformation process is a bit more involved than one might suspect. Thompson grapes, one of the varieties commonly used for wine production and table consumption, are shown here as they grow in a vineyard near Reedley.

Irrigation water for the farmer in this area is supplied by the Bureau of Reclamation's Friant-Kern Canal. The canal carries water from Friant Dam on the San Joaquin River, southerly for supplemental and new irrigation supplies in Fresno, Tulare, and Kern Counties, an area of almost 1 million acres of highly fertile land in this southern portion of the San Joaquin Valley. The irrigation facilities are part of the Bureau's Central Valley project.

After adequate irrigation, sunshine and nutrients, these grapes grow ripe and ready for har-

④

⑤

⑥

vesting. This mechanical grape harvester in operation on a Thompson seedless grape vineyard near Fresno has greatly reduced the laborious work of grape-picking.

This closeup of the mechanical grape harvester shows the sifting method used to separate fruit from vine. ①

After harvesting, the grapes are loaded onto a truck, which will transport them to their next destination—the packing plant. ② ③

Those grapes which will be turned into raisins require an additional step before trucking. Here, farm workers are turning paper trays of harvested Thompson seedless grapes in a vineyard near Sanger on the east side of the San Joaquin Valley. This process provides for even drying by the sun. Considered the raisin capital of the world, this area is replete with vineyards. ④

After the grapes are dried for raisins, they are rolled up in the paper trays. From the field these rolls are taken to a nearby plant for further processing, then shipped to the consumer. ⑤

The final result—delightful, ready-to-eat raisins. ⑥

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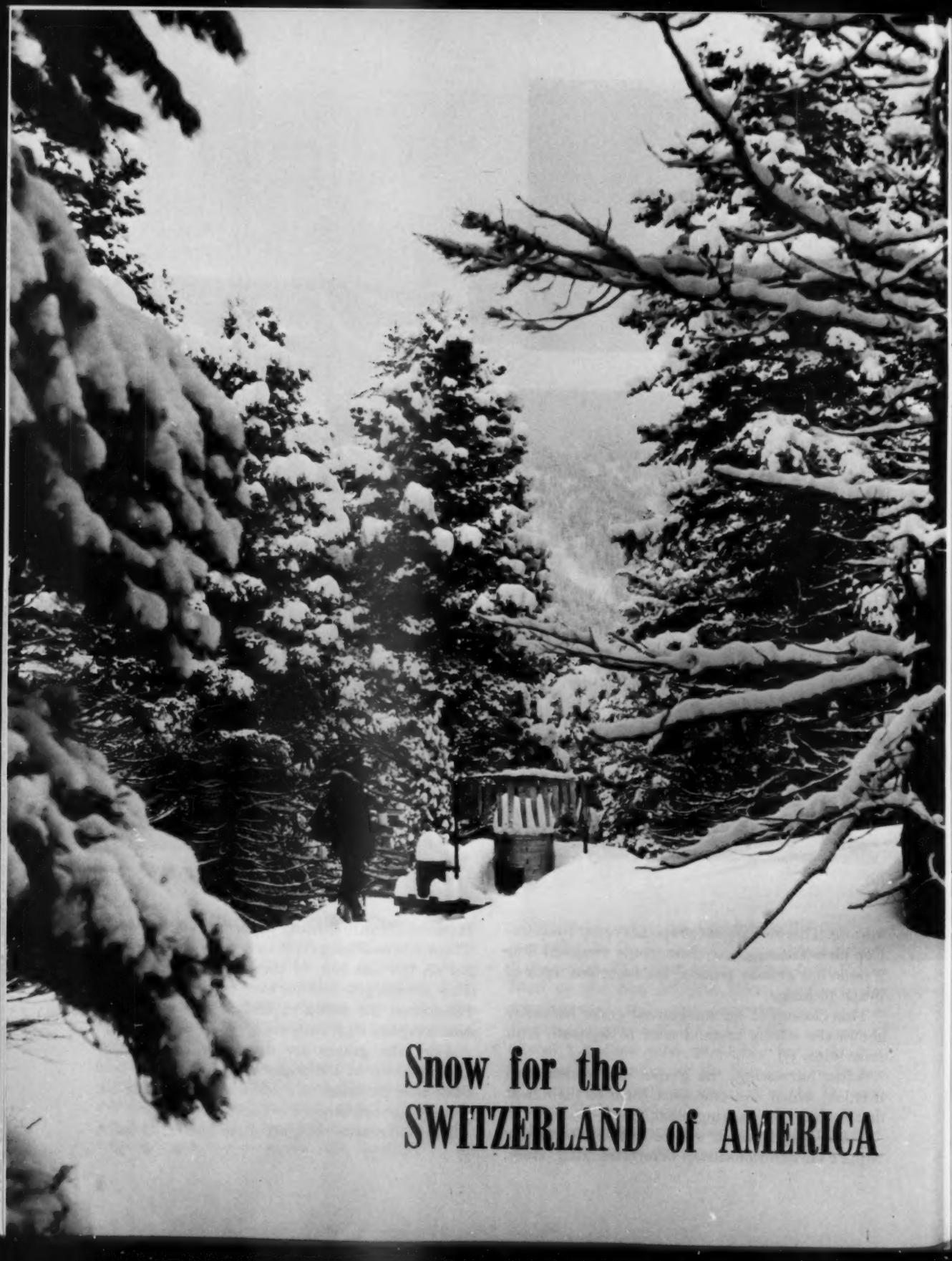

Snow for the
SWITZERLAND of AMERICA

by **WILLIAM J. DOUGLAS, Research Meteorologist, Engineering and Research Center, Bureau of Reclamation, Denver, Colo.**

ON the narrow highway, wending a serpentine path that offers spine-tingling views, cars bearing out-of-state licenses form an almost constant summer caravan under the face of southwest Colorado's spectacular San Juan Mountain range.

Even now, while the calendar proclaims summer, there is a chill to the winds that play about the 14,000-foot peaks here in what is known as the "Switzerland of America."

Of the thousands of tourists who visit this alpine wonderland, it is likely that few of them are aware that nearby is the site of a scientific research project that has captured international attention and that holds immense promise for water-short areas of the western United States.

Colorado River Basin Pilot Project

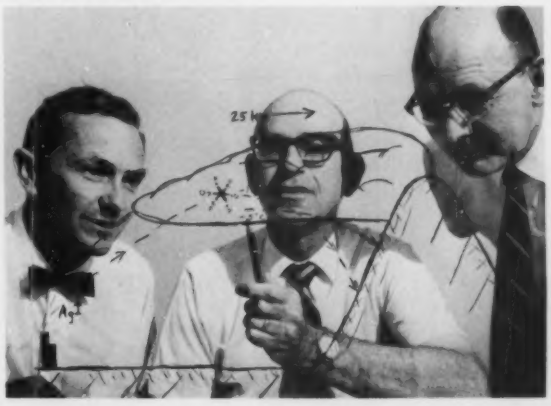
It is the Bureau of Reclamation's Colorado River Basin Pilot project, designed to determine how cloud-seeding can most effectively be applied on a large-scale basis to augment runoff of the Colorado River, the lifeline of the seven states which it touches or to which it contributes its runoff.

As summer of 1972 wanes, teams of meteorologists and other scientists, technicians, and student research assistants prepare for the third consecutive winter season of cloud-seeding operations in the project area that lies along the windward side of the Continental Divide, rooftop of the Nation. The work is not confined to men of science. Housewives, ranchers, and a sprinkling of high school students are among those employed in the pilot project.

The project area (1,600 square miles), is larger than the entire State of Rhode Island. The project commands the services of some 150 full- and part-time employees. More than 200 instruments and gages are installed and used in and around the

These students are measuring and recording dimensions of flowering plants near Williams Fork Lake in the San Juan Mountains. They are associated with the ecological studies of the San Juan Mountains.

Dr. Archie Kahan shows Clem Todd (L) and Robert Trainor (R), the influence of silver iodide (AgI) on a supercooled cloud, and the trajectory of snowfall on the face of a mountain barrier. All three are employees of the Bureau of Reclamation.



The Springhill precipitation gauge is serviced by this operator who, during his 3-day stay, maintains the silver iodide generator, tracks balloon releases, and services other weather recording instruments.

target area. They record great masses of data on wind and temperature, pressure and precipitation, on a day-to-day, hour-by-hour basis.

From these data, Bureau of Reclamation scientists expect to provide definitive answers to the questions: What additional precipitation does cloud-seeding 1972 model, provide? At what cost? With what reliability? Under what conditions? And what are the physical, social, and environmental considerations?

Project Skywater

To explore these and other issues, the Bureau of Reclamation conducts a $6-million-a-year research program dubbed, "Project Skywater." It involves special studies and activities by 44 contractors in 20 states. The Colorado River Basin Pilot project is one of three field programs (others are in North Dakota and Nevada) that represent a critical link in the scientific transition from basic research to operational adaptation.

Project Skywater is directed by the Division of Atmospheric Water Resources Management at the Bureau's Engineering and Research Center in Denver. The project was born in 1961, when the Congress appropriated $100,000 for Reclamation to explore cloud seeding as a possible water resources tool.

The Colorado River Basin Pilot project was conceived in 1968, but because of extensive planning requirements, seeding was not begun until the winter of 1970–71.

The operation involves careful analysis of winter storms as they approach the mountainous target area. As warm moist air is forced up and over the Continental Divide, clouds are formed which deposit much of their burden of snow on the southwest-facing slopes of the massive San Juan Mountains.

Seedable Storms

Based on criteria related to temperature, humidity, and other factors, about half the storms are considered "seedable." When a "seedable" storm comes along, a random decision is made whether or not to treat it—that is, to seed it with silver iodide crystals produced by a network of 33 ground generators located upwind of the target area. Only about half of the "seedable" storms are seeded.

Extensive data are collected on each storm by a host of airborne and ground instruments to be analyzed on the basis of seeded versus unseeded cases. After two winter seasons of operations, Project Skywater officials say a preliminary comparison shows a significant increase in precipitation from seeded storms. But a more comprehensive assessment must await the full term of the pilot project—that is, four, possibly five winter seasons of randomly seeded storms that meet criteria, followed by a scientific examination of the results.

"We are searching," says Dr. Archie M. Kahan, Chief of the Bureau of Reclamation's Division of Atmospheric Water Resources Management, "for a faint signal against a very noisy background, unfailing scientific evidence that man can impose a positive effect on a natural phenomenon that varies widely and frequently."

Dr. Kahan joined the Bureau in 1965 after a distinguished career in which he engaged in research and administration at Texas A&M University and later at the University of Oklahoma. Notwithstanding his scientific restraint, Dr. Kahan occasionally exhibits a romanticist's appreciation for such sights as a flotilla of fleecy clouds parading across a blue summer sky.

Lifeblood of Rivers

Indeed, summer clouds and their stimulation for added rainfall are an important part of Project Skywater research. But in directing the Colorado River Basin Pilot project, Dr. Kahan and his staff are most concerned with winter storms that provide the lifeblood of all western streams and rivers.

Snows deposited in the high mountains feed them all. The river's flow is governed by the amount and character of the mountain's snowpack. The snowpack is, in turn, a product of the uncertain and infrequent storms that travel the winter skies over the Rockies.

"Mankind has yet no way of influencing the frequency of such storms," explains Dr. Kahan, "Nor can we influence precipitation from all kinds of atmospheric circumstances. But we *are* learning the means by which we can improve the precipitation production of certain kinds of clouds."

An important stepping stone toward this knowledge was provided by Lewis Grant, professor at Colorado State University and more recently a consultant to Project Skywater. During the late 1950's and early 1960's, Professor Grant and his staff conducted seeding experiments on winter-

time clouds in the Colorado Rockies for both the National Science Foundation and for the State of Colorado.

Silver Iodide is Released

After hundreds of seedings, they found that precipitation increased when silver iodide crystals were released into clouds whose uppermost tempertures ranged between minus 5° and minus 23° Centigrade. It is in this temperature range that silver iodide functions best, and that naturally occurring materials are least effective in furnishing the nuclei needed to produce precipitation.

The critical role of these temperature values in seeding winter clouds is well established, but the pilot project now seeks additional data.

"Simply stated," says Dr. Kahan, "our objective is to be able to report that, by cloud seeding, we can produce x acre-feet of additional water at a cost of y dollars and with a statistical reliability of z. We hope to accomplish this in a socially acceptable and environmentally sound fashion. We in the Bureau of Reclamation have the responsibility of assigning hard values to the unknowns—x, y, and z."

When the pilot project was conceived in 1968, the Bureau of Reclamation called on Professor Grant and Colorado State University to prepare the design. It proposed the random seeding of storms meeting specific criteria for a period of at least four winter seasons, to provide a number of cases of seeded and unseeded storms sufficient to yield statistically significant results.

Harold Halverson, as do many ranchers near the Durango–Pagosa Springs area, operates a burning silver iodide generator.

San Juan Region Chosen

Selection of the operations area was of major importance. The San Juan region was chosen for its contribution to the Colorado River runoff through a number of tributaries; for the presence of an existing network of precipitation gages and other instruments; and because virtually the entire region is publicly owned.

Individual contractors were selected to conduct seeding and field activities, to install the instruments and to collect data for the full period of the project. EG&G, Inc., through its Environmental Services Operation at Albuquerque, N. Mex., is the seeding contractor and Western Scientific Services, Inc., of Fort Collins, Colo., is responsible for the instrumentation and data acquisition. Both have established offices at Durango, Colo., headquarters for the project.

Communities Question Project

Residents of mountain communities near the project area were less than enthusiastic when the project was first announced. They voiced fears of record amounts of snow, of spring floods and winter hazards, of an abbreviated summer tourist season, of groundwater conditions that would imperil mines that contribute heavily to the area's economy.

These and other concerns were answered (and a spirit of mutual trust was born) in a series of public meetings in several comunities: Silverton, Telluride, Ouray, Lake City, and Pagosa Springs.

Three times hearings were conducted in those communities where interest ran high. To keep residents and local and State officials fully advised of developments, a Project Skywater newsletter was developed by the Division of Atmospheric Water Resources Management and is mailed at frequent intervals to a list that has grown to nearly 250 persons.

At public meetings, in correspondence, and in frequent and casual conversations between Proj-

ect Skywater officials and local residents, the exchanges were sometimes brisk and always honest. They demonstrated that the project was flexible, and that residents had the opportunity to shape it in significant ways.

Avalanche-Prone Area

"We live in the most avalanche-prone area of the Nation," local citizens said. "What do you propose doing about this threat?"

There are, in fact, 49 specific avalanche runs that intersect the "Million Dollar Highway" (U.S. Highway 550) that links Silverton and Ouray. These steep courses pose a very real hazard to motorists in the winter. But, it is not known whether or not additional snow would increase this hazard. What, indeed, might be done?

Even though the highway and the communities are outside the seeding target area, the Bureau turned to the University of Colorado's Institute of Arctic and Alpine Research (INSTAAR) for an intensive study of avalanches to determine what causes them to occur at particular moments, and how they may be forecast, diverted, or controlled.

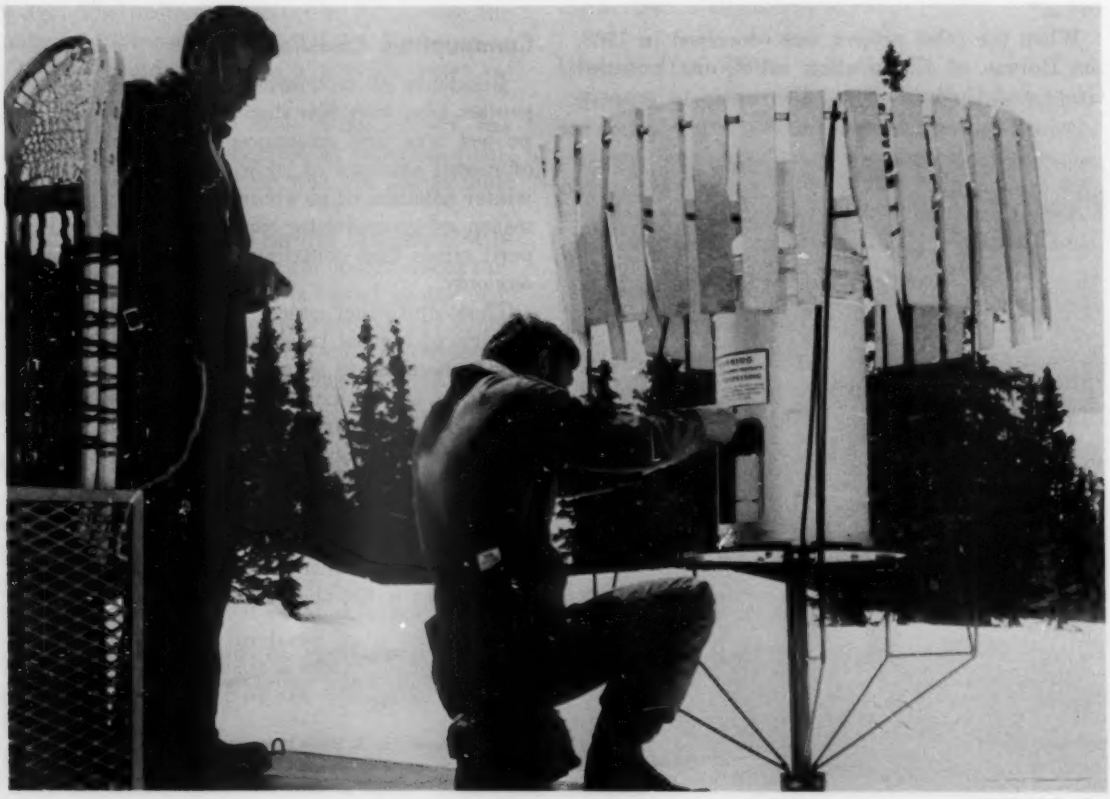
Howitzers Used to Shoot Avalanches

Highway crews and ski operators have used recoilless rifles or howitzers to shoot avalanches, the most common control technique. Not always, of course, have they beaten nature to the punch. The Colorado Division of Highways uses three 75 mm. howitzers, on loan from the National Guard, in its avalanche-control program. During the 1960's, the Division built a massive concrete snowshed at the site of one of the worst avalanche runs atop Wolf Creek Pass, which lies nearly at the geographic midsection of the Colorado River Basin Pilot program.

Despite these controls, however, little effort has been directed in this country to accurate understanding of the avalanche phenomenon or to innovative steps to control the devastating slides.

Last winter, in performance of the Reclamation

Like all instruments used by Project Skywater, this precipitation gauge must be carefully operated; here, the chart is being changed.



Lifting components for the San Juan weather station—the highest unmanned station in the United States—is this French-made turbo jet helicopter.

contract, a five-member INSTAAR team took up residence in Silverton and established a mountain-top observation post where, during snowstorms, they made exhaustive studies of snow density and accumulation in known avalanche areas. They also measured and evaluated scores of slides during the winter in an effort to build an avalanche "profile" from which new ways could be found to anticipate and control nature's "white terrors."

Environmental Effects

What are the environmental effects of cloud seeding? Environmental considerations previously viewed academically attracted new recognition with the pilot project. Already in progress was a special study by a University of Michigan research team into the ecologic effects of weather modification. Completed in 1969, the study suggested any changes produced by cloud seeding probably would be gradual and subtle, some for better, some possibly for worse. But, research was needed!

To explore the study's theoretical findings, an intensive ecologic investigation was ordered as part of the Colorado River Basin Pilot project. It is being conducted by Colorado State University, the University of Colorado, and Fort Lewis College of Durango, Colo.

The ecologic studies continue year round, and emphasize items most sensitive to ecologic change—that is, living things that provide the earliest and most reliable barometers of possible change. Among them, curiously, are boreal toads—amphibians that are among the most fragile inhabitants of the alpine ecosystem.

These and other occupants of the project area—squirrels and shrew, elk and rabbits, flowers and native grasses—are counted and catalogued so that their numbers and growth may be monitored in selected test plots throughout and beyond the period of the pilot project.

Another part of the ecologic study involves the reconstruction of the area's climatic history. No formal records now exist, so tree-ring dating is in progress to enable scientists to build a weather history and ot determine what trends may already be in progress as a natural step in the area's evolution.

Natural Change in Climate

"It is eminently reasonable to postulate that the San Juan Mountains may be experiencing a (natural) shift in temperature and precipitation," say the ecologic investigators. "If this is true, then it follows that the ecological conditions of the target area are already shifting in response to this natural change in climate."

Thus what began, 4 years ago as a research program to evaluate cloud seeding as a tool to augment water for the Upper Colorado River Basin has taken on a much deeper character, with far greater dimensions than originally envisioned.

"We have not lost sight of out goal," says Dr. Kahan. "Our mission remains one of determining the worth of cloud seeding as an economic, efficient, socially acceptable and environmentally sound water augmentation tool. The complexities of that challenge are nothing short of staggering, but they are enormously exciting. We have made enormous progress. We shall achieve our goal.

"Particularly gratifying is the awareness that scientific investigation spawns new ideas, new objectives, and new benefits to mankind. We have rediscovered these truths with the pilot project."

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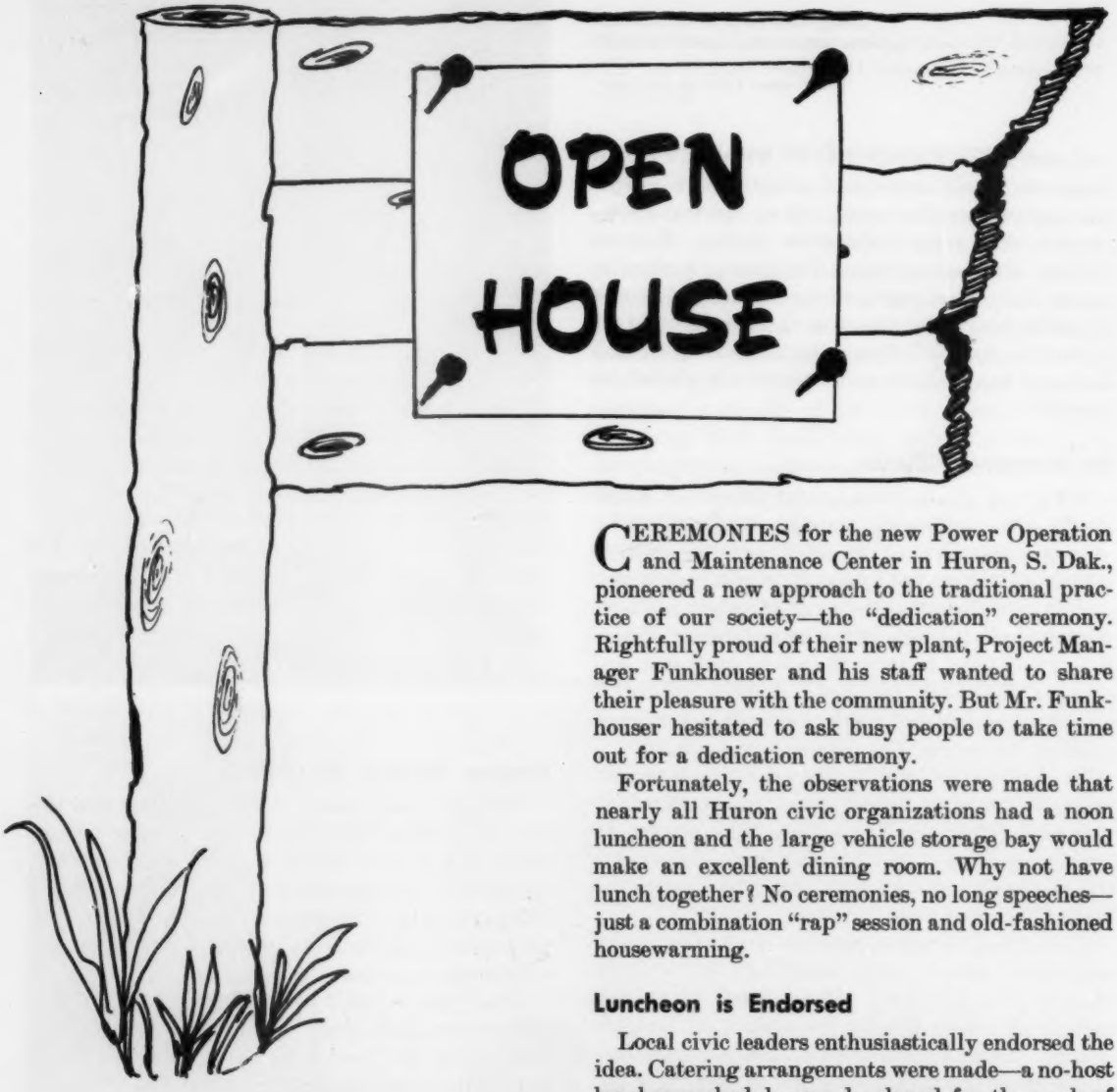


by **GEORGE W. CAREY,**
Bureau of Reclamation,
Missouri-Oahe Projects Office,
Huron, S. Dak.

CEREMONIES for the new Power Operation and Maintenance Center in Huron, S. Dak., pioneered a new approach to the traditional practice of our society—the "dedication" ceremony. Rightfully proud of their new plant, Project Manager Funkhouser and his staff wanted to share their pleasure with the community. But Mr. Funkhouser hesitated to ask busy people to take time out for a dedication ceremony.

Fortunately, the observations were made that nearly all Huron civic organizations had a noon luncheon and the large vehicle storage bay would make an excellent dining room. Why not have lunch together? No ceremonies, no long speeches—just a combination "rap" session and old-fashioned housewarming.

Luncheon is Endorsed

Local civic leaders enthusiastically endorsed the idea. Catering arrangements were made—a no-host luncheon schedule was developed for the week of November 29 to December 3, 1971. We even wheeled in specialized equipment for decorations.

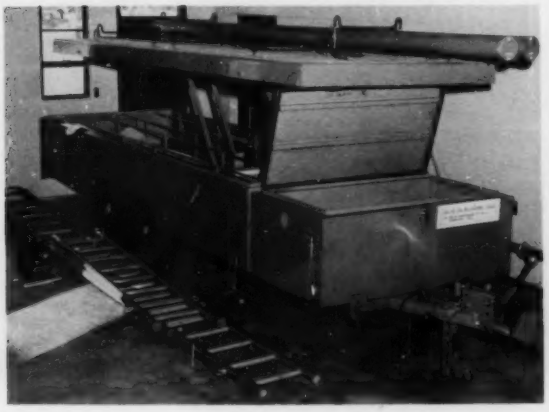
On Monday, November 29, the Sertoma Club kicked off the first of a series of luncheons including those of the Lions, Kiwanis, Rotary, Optimist, and High Twelve.

The local civic organizations, as well as others interested, including Bureau of Reclamation employees, enjoyed the luncheons and had the opportunity to inspect the new facility and the specialized equipment used to maintain the Bureau's power transmission system. About 300 people attended.

Unlike most "open houses", the Bureau's Operation and Maintenance Shop Building provides headquarters and shop facilities for all maintenance personnel in Huron plus storage bays for specialized equipment.

For 5 days well-attended luncheons were held in the storage bay.

Used as decoration, this 345 KV Hotline Trailer added to the atmosphere of the luncheon. It is used to store tools needed for work with high voltage transmission lines.



The 60- by 120-foot building provides headquarters and shop facilities for electrical, electronic, meter, and relay crews; it also provides storage for specialized equipment used to maintain the Bureau's power transmission system. The foundation is concrete caissons spanned by concrete grade beams. The upper roof beams are precast, prestressed concrete double tees supported by concrete walls. Curtain walls, nonbearing exterior walls, and all interior walls are of concrete masonry unit construction. Roofing is foamed-in-place rigid urethane insulation with silicone rubber coatings.

Construction Began in 1950

Construction of facilities began in 1950 for marketing the power generated at the hydroelectric plants on the main stem of the Missouri River. Facilities constructed since that time, under the Huron Office supervision, include over 3,600 miles of transmission line and 37 substations with approximately 3 million kilovolt-amperes ((kv.-a.) of capacity in South Dakota and adjacent states.

During the summer of 1970, construction was completed on the 345-kv. line running from Fort Thompson, S. Dak. to Grand Island, Nebr., including new substation facilities at each end of the line. These new facilities relieved a critical power supply problem in Nebraska. They also served as the major link permitting the integration of Nebraska's summer peak loads with North and South Dakota's winter peak loads, thus reducing required overall generating capacity. This is the first extra-high-voltage transmission line constructed by the Federal Government in the Missouri River Basin.

Markets Electric Power

The Bureau's Huron office is responsible for marketing electric power in South Dakota, western Iowa, eastern Nebraska, and southwestern Minnesota. The office is also responsible for conducting studies and preparing design data for transmission lines, substations and other facilities required to deliver power to load centers.

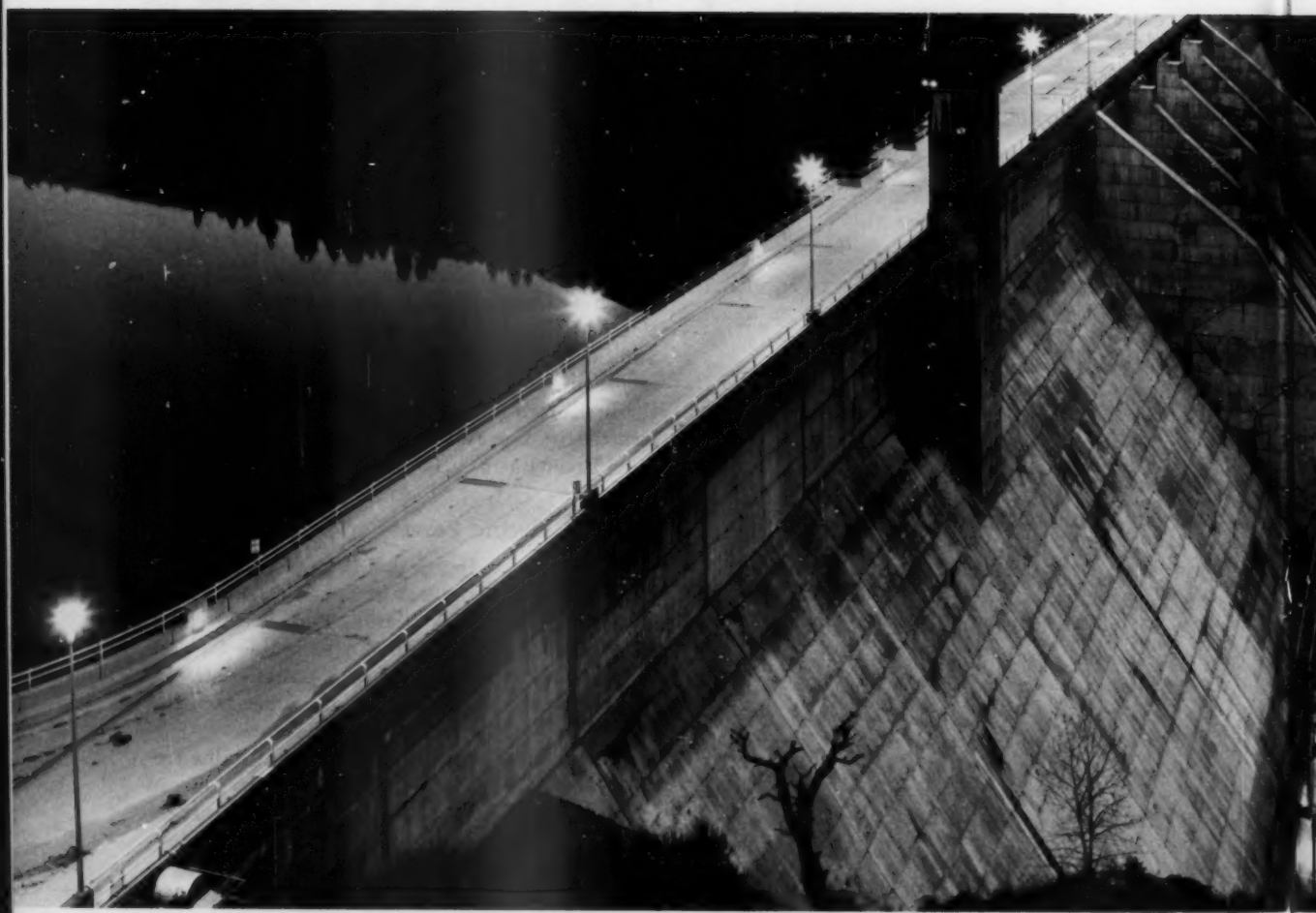
The Huron office establishes and maintains frequent contact with existing and potential Bureau customers, and operates and maintains transmission lines, substations and other facilities including control, communications and protective devices. # # #

by HAROLD E. ALDRICH, Regional Director,
Bureau of Reclamation, Region 6, Billings, Mont.

Ashes to Ashes

DUST to DUCKS

Canyon Ferry Dam which creates Canyon Ferry Lake is a concrete, gravity type, 225 feet high structure with a spillway capacity of 150,000 cubic feet per second.



The mudflat caused by the drawdown will be enclosed by a dike up to 15 feet high and nearly 3 miles long.

AT 10 a.m. on March 23, 1972, the Bureau of Reclamation opened bids at Townsend, Mont., for the construction of dust abatement installations at Canyon Ferry Lake. In many ways, that event was just another bid opening. In one way, however, it marked a significant milestone in the history of the Bureau's program for a livable environment.

Back in 1902, the basic Reclamation Act made no mention of multipurpose reservoirs, nor of their effect on the environment. The body of law under which the Bureau of Reclamation operates today is the result of slow and sporadic development, largely under conditions far removed from today's public demand for full environmental consideration. Although people from all over the Nation are enjoying recreational, fish and wildlife, and other environmental benefits on many of the older projects built by the Bureau of Reclamation, these benefits are provided incidentally by reservoirs justified and built for other purposes.

Parched and cracked, the lakebed soon turns to blowing dust.

Looking across the upper end of Canyon Ferry Lake from the west shore, one can see the blowing dust sweep across the reservior shoreline.

Now, An Era of Change

The Canyon Ferry Unit of the Pick-Sloan Missouri Basin program was born in this era of change. It was authorized for specified multipurpose use, but the public demanded a vastly more efficient utilization of its water supply and of the facilities used for its regulation and enjoyment. It was used for flood control purposes from its first filling in 1954, but there was no space officially allocated to flood control in the reservoir area until 1966.

Although provision was made during construction of the dam for fish and wildlife enhancement recommended by the Montana Department of Fish and Game, the Bureau had no mandate to stabilize the lake level during goose-nesting period, which it has done whenever possible.

The Bureau has constantly worked to provide the best possible uses of the available water supply, even though the users were frequently highly competitive. Unfavorable impacts such as reservoir fluctuation, mudflats and blowing dust were inevitable.

The original operating plans for Canyon Ferry had to assume—in the absence of specific enabling legislation—that water storage involved certain ecological costs the community and society were willing to pay in exchange for the benefits derived.

Government's Policy for Good Environment

The National Environmental Policy Act of 1969, together with other state and Federal legislation relating to environmental pollution ushered in a new era. It is now a recognized policy of the Federal Government to use all practicable means to create and maintain conditions by which man and nature can live in productive harmony.

Canyon Ferry can no longer be regarded simply as a storage reservoir for certain purposes—it is what the ecologists call a "manmade lake," with all the wide-ranging ecological and social consequences that the name implies. Its storage water, its overlying air, its plant and animal life, together with the people who pursue their activities in the lake area, now constitute a classic example of the ecosystems that must be considered in resource development and use.

The Bureau of Reclamation is proud to share with the people of the Canyon Ferry community the responsibilities as trustees of that ecosystem. These are also shared by the National Park Service, Bureau of Sport Fisheries and Wildlife, and the Montana Fish and Game Departmnet, who assisted the Bureau in preparing the plan for dust abatement and wildlife preservation and enhancement. The Bureau believes that when the program is completed, it will enable local people and succeeding generations to attain the widest range of beneficial uses of the total environment without degradation or risk to health and safety.

But the local people don't have to wait for future generations to realize the favorable impact of this work.

The Dust Problem

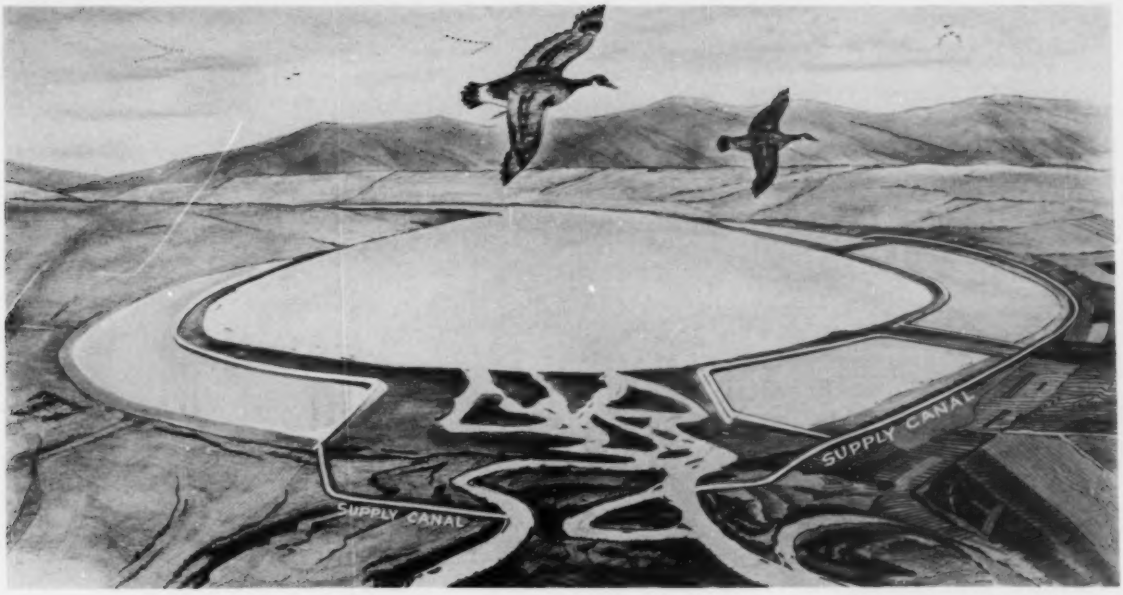
Unlike most tides which are daily, the fluctuation of Canyon Ferry Lake is annual. The inevitable result is the exposed lakebed dries during the low water and the fine sand is swooped into the air by gusts of wind.

When these dust storms sweep across highways, motorists have difficulty seeing the road and oncoming traffic. Windowsills of Townsend dwellings are coated with dust. Dust-laden crops bear mute witness of the farm problem.

But, the Bureau of Reclamation is resolving the problem—the Canyon Ferry dust control program is being undertaken which, at the same time, will transform the mud flats from which the dust comes, to permanent pools of shallow water which will provide nesting habitat for waterfowl.

The work proposed (as shown in the artist's concept) includes about 10 miles of silt-retention dikes of a maximum height of 15 feet to be constructed on both sides of the reservoir, creating 1,870 acres of ponds. These will be constructed di-

The dredge tailings (foreground) will be used to construct zone 2 of the Westside Dike in the dust abatement program.



The artist's concept of the supply canal.

rectly on the lakebed by using gravelly materials from nearby borrow areas.

Silt deposits on the lakeside of the dikes will be excavated by hydraulic dredge and deposited behind the dikes to eliminate dust sources from the lakeside areas. The deposited material will act as a sealant for the ponds and dikes.

The program will require an estimated expenditure of $5,100,000 for construction of canals, dikes and dredging operations over a period of about 5 years. This construction will have a noticeable impact upon the local and regional economy. On-site employment is estimated to equal about 80 man-years to accomplish the construction work.

The work involved will employ labor from various trades, including equipment operators, truck drivers, dredge operators, dredge hands, mechanics, cement masons, laborers, foremen and supervisors. In addition, substantial quantities of fuels, lubricants, and other materials and supplies will need to be purchased. However, the work will be seasonal due to climate, ice cover and water elevations in the reservoir.

A Bonus for the Community

A feature of this construction which may be considered a bonus for the community is that the Bureau scheduled it over a 5-year period for two reasons: (1) To eliminate the need for the huge capital investments in machinery and equipment a "crash" program requires and (2) to permit local contractors to incorporate the seasonal part of this job into their construction schedules. Except for dredging, local and nearby contractors were in an excellent position to compete in bidding since all work was set aside for small business.

Islands for Waterfowl

The impoundments will be filled with water to a depth of 3 to 5 feet by ditches from the Missouri River upstream from the ponds. A system of waterways and open drains between impoundments will protect the facilities from excessive surface runoff from intensive rainstorms. Islands for waterfowl nesting and resting will be constructed during the dredging operations.

A section of the lake, a wasteland and a source of dust when intermittently exposed, will thus be converted to an area of beneficial use without changing the basic functions of Canyon Ferry Unit. Problems created by the dust blowing from this section of the lake will be greatly reduced. At the same time, excellent aquatic wildlife habitat will be developed at the impoundments.

The quality of life will be improved and adverse effects on livestock and forage crops will be reduced, thus benefiting the economy of the area.

This aerial view shows the location of the proposed canal and dikes. The town of Townsend, Mont., is in the foreground.

Marsh Attracts Ducks and Geese

The shallow marsh areas will be highly attractive to the breeding population of ducks and geese using the Missouri River, which is in one of the major flyways of Montana. The impoundments will complement the use of adjacent Federal land acquired for Canyon Ferry Lake, administered by the Montana Fish and Game Department for recreation and fish and wildlife purposes.

Safe nesting areas for geese will be available along the perimeter of the impoundments and on the islands planted with suitable vegetation. Stable water levels in the impoundments will encourage aquatic vegetation for food and cover. The marsh area will accommodate an estimated 600 man-days of hunting each year plus trappings for fur bearers.

Ecology Classroom

With the abundance of wildlife anticipated, the area could become an "ecology classroom" as a demonstration of what man can do when he enhances the environment for the benefit of both wildlife and man.

When completed, operation and maintenance of the proposed dikes, water supply facilities, and relief drains will be performed by personnel of the Bureau of Reclamation, in cooperation with the Montana Department of Fish and Game. Bureau personnel will periodically adjust river diversions to supply canals and water deliveries into pounds, and will perform necessary maintenance work on the facilities.

The Montana Fish and Game Department, in furtherance of the development of new wildlife facilities at Canyon Ferry Lake, has indicated its intent to share costs of the plan by assuming operation, maintenance, and replacement costs, estimated at $20,000 annually. That agency will administer the wildlife areas as a part of the current management plan for the Federal lands of the Canyon Ferry Unit. Bureau of Reclamation and State officials will soon meet to revise and update the existing plan for management to include the new dust control program. # # #

Along with the marsh which will be provided for ducks and geese, a total of 700,000 of these 4 to 6 inch rainbows will be planted in Canyon Ferry Lake this summer.

WATER Quiz

[1] The Bureau's Central Valley project in California produces tremendous quantities and many varieties of fruit. What is the name of the California-grown fruit shown here? →

a. quince
b. persimmon
c. Scarlet Pearmain apple
d. pomegranate

[2] In science, water is a standard for the representation of certain units. Some of these are:

a. the liter
b. the calorie
c. both of these
d. neither of these

[3] What is the purest natural source of water?

a. snow
b. mountain stream water
c. rain

[4] What connection is there between the high stairs of these Sacramento homes and the Bureau of Reclamation? →

[5] List these events in order of their place in the water cycle, starting on a sunny afternoon.

a. rain or snow
b. evaporation from water and plant surfaces
c. condensation
d. runoff—such as streams and underground water

Answers on page 24.

Yesterday in Our Magazine

THE RECLAMATION ERA—1935

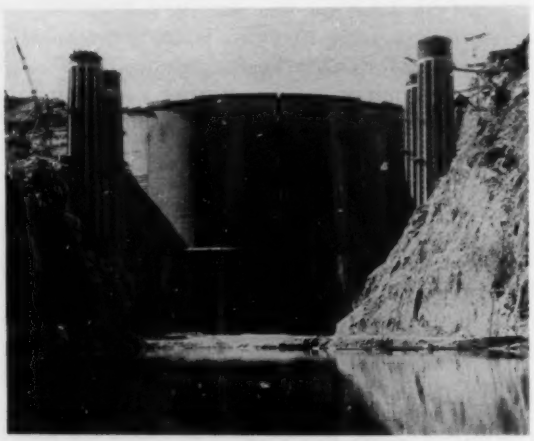
The Boulder Canyon Project

THE results to be expected from the construction of the Boulder Canyon project are as follows:

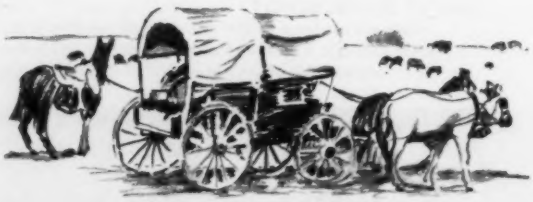
1. Will help alleviate the serious economic situation brought about by the general[ly] depressed conditions throughout the country.
2. Will provide flood control.
3. Will provide an adequate water supply for irrigation and domestic use.
4. Will provide silt control.
5. Will improve navigation on the river below and above Black Canyon.
6. Will create a new recreational area.
7. Will permit the generation of power, the returns from the sale of which will repay the entire cost of the project.

On July 30, 1930, President Hoover signed the deficiency act, carrying an appropriation of $10,660,000 for initiating construction of the project. Four days later Order No. 436 was signed by the Secretary of the Interior directing the Commissioner of the Bureau of Reclamation to commence construction on Boulder Dam and the Bureau actually put men to work at the damsite on that day.

Although not so intended in the original setup, this project became the first to aid in the problem of unemployment during the years of depression. Work was going ahead on the drawings and designs in the Bureau's Denver office when word was received from President Hoover to start construction as soon as possible in order to aid in alleviation of the unemployment conditions.



Boulder Canyon project, Arizona–Nevada—Reservoir starts to fill.



today...

Reclamation Era—1972

THE Colorado River has been a menace to life and property along its banks for many years. The need for a comprehensive plan of development to check the enormous energy is being met by the Boulder Canyon project. It now includes Hoover Dam (prior to 1947, known as Boulder Dam), the powerplant on the Colorado River, and the All-American Canal System. Lake Mead, the reservoir behind Hoover Dam, with a total capacity of nearly 30 million acre-feet, will hold the entire flow of the river for 2 years.

The results expected in 1935 from the construction of the Boulder Canyon project were achieved and still are being realized:

1. It did help alleviate the serious economic situation by employing an average of 4,000 men for a 4-year period with an average payroll of $600,000 per month.

2. There has been no flooding in the lower Colorado River since the dam was built.

3. It supplies water for irrigation to 500,000 acres of land in the United States and 500,000 acres in Mexico; and it supplies water for domestic and industrial use to more than 10 million people.

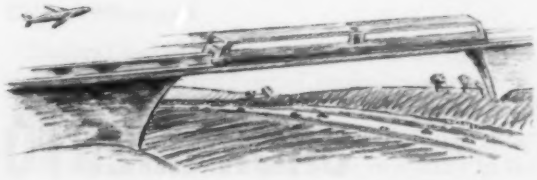
4. It provides silt control. Water leaving Hoover Dam is clear.

5. Upstream from the dam, the river is navigable for 110 miles when the lake is full. Below the dam, the river is navigable 67 miles to the next dam downstream.

6. Lake Mead has become one of the Nation's most popular recreational areas. More than 5 million persons visit the area each year to sightsee, swim, fish, boat, and camp.

7. The sale of electrical energy will pay back the cost of the project plus interest by 1987 except for $25 million allocated to flood control.

Hoover Dam and Lake Mead as they look today.



SACRAMENTO-SAN JOAQUIN DELTA

A MAN-MADE ENVIRONMENT

by **JIM COOK, Acting Chief, Delta and Bay Area Branch, Regional Planning Office, Bureau of Reclamation, Sacramento, Calif.**

THE 450-mile-long Central Valley lies in the northern and central portion of California, bounded on the east by the Sierra Nevada Mountains and on the west by the Coast Range. The Sacramento River flows southerly and the San Joaquin River flows northerly through the valley floor. They join in the Delta and reach the Pacific Ocean after passing through the Delta, and Suisun, San Pablo, and San Francisco Bays.

The combination of rivers, sloughs, islands, and mudbanks commonly known as the Delta lies at the confluence of the Sacramento and San Joaquin River systems about 40 miles northeast of San Francisco. The 740,000-acre Delta contains about 50,000 acres of water surface consisting mainly of over 700 miles of meandering waterways which separate islands and tracts of rich farmland.

The Delta's land area consists of peat, alluvium and organic soils from 5 to 80 feet below sea level. Water levels in the Delta channels rise and fall from 3 to 5 feet each day due to the tidal influence of the Pacific Ocean. The Delta is extensively developed for agriculture.

A Tidal Marshland

Prior to 1849, settlers avoided the Delta, considering it a tidal marshland inhabited by wildfowl and beaver. With the discovery of gold at Sutter's Mill in the foothills of the Sierra Nevada, the sedentary way of life of the few settlements strung out around the Delta was completely disrupted as tens of thousands of people poured into California. New settlements sprang up around the early Spanish land grants which skirted the Delta between Stockton and Sacramento. The influx created a need for a more intensive and diversified agriculture.

Many miners, frustrated in their search for gold, sought a more certain fortune by tilling the rich soil along the banks of Delta waterways. As the demand for foodstuffs intensified, the farmers encroached farther and farther into the Delta marshland. Low artificial mounds, or "shoestring levees" as they were appropriately called, were constructed to hold back Delta waters. However, they were capable of withstanding little more than a high tide.

Winter flooding in the 1850's demonstrated the need for levee protection of Delta farmlands. Early attempts to construct levees were hampered by high costs and a strong feeling that floods could be controlled by facilities in the Sacramento Valley.

Development Begins

Great strides were taken in the next half century in the development of reclamation techniques and equipment. Mechanical power was applied to dredging, levee building, ditching and land clearing. Pumps were introduced in 1876 to control water levels on reclaimed land. During the 1870's, interest in swampland reclamation was at a peak. Levee building projects ultimately transformed the Delta from an imperfectly drained flood plain to a productive farming region.

In addition to reclaiming the land area, new fish species—striped bass, American shad, and white catfish—were introduced. Quail and other game birds were brought into the Delta and released. Imported varieties of orchard and field crops were planted and new breeds of livestock were introduced into the area.

Ironically, man's attempts to develop the seemingly boundless resources of California were producing problems as far reaching as his achieve-

These hearty fishermen display the fine fish that can now be caught in the delta area.

ments. From 1860 to 1914 more than 800 million cubic yards of mining debris from upstream mountains passed through the Delta, raising the beds and constricting all channels. In addition, higher levees and reclaimed land reduced the flood plain area. Thus, salt water began to penetrate further into the Delta.

River Flows Decrease

This problem was further compounded when flows of the Sacramento and San Joaquin Rivers began to decrease due to upstream development. Also, water of the San Joaquin River system deteriorated, hence poor quality water flowed in the river for longer periods each year because of increasing agricultural use and waste water return flow in upstream areas.

An interesting indicator of water quality in the Delta area during these early years was provided by operating records of the California and Hawaii (C. & H.) Sugar Co.'s water barge. During years of low stream-flow into the Delta, the high salt content offshore from the company's plant at Crockett on the Carquinez Strait required hauling water from the interior Delta to meet processing needs. During the drought of 1918–20, the search for fresh water carried the barge almost to the city of Stockton on the eastern edge of the Delta.

This drought resulted in extensive abandonment of newly irrigated lands in the San Joaquin Valley where rapid development of irrigation pumping had lowered the ground water. Salinity in the Delta forced virtual abandonment of the Delta channels as a source of water.

In 1921 the State Legislature authorized an extensive investigation by the State Engineering Department to develop a comprehensive plan for conservation, control, distribution and use of all the waters of the State for the most beneficial purposes.

CVP Authorized

Federal and State interests spent years studying designs and the funding of needed water works. After litigation and negotiation between areas of water supply and areas of water need and after lobbying by various interests, the Secretary of the Interior was authorized by the 1937 Rivers and Harbors Act to construct a Central Valley project (CVP) in accordance with Reclamation law.

With the advent of the Central Valley project, the waterways of the Delta became part of a water conveyance system. Water from the upstream reservoirs is drawn across the Delta channels and

through the Delta Cross Channel (CVP–1951), a mile-long channel constructed between the Sacramento and Mokelumne River systems, to export pumps serving the Contra Costa Canal (CVP–1948) and the Delta Mendota Canal (CVP–1951).

In addition to meeting contract requirements for water quality at these export pumping locations, the cross-Delta water transfer has assured availability of quality water to interior Delta water users since the construction of Shasta Reservoir (CVP–1945); although this was not an expressed purpose of the project.

In 1959 the California Legislature authorized the California State Water project. In 1960 the electorate ratified this legislation enabling the start of advanced planning and construction of the State Water project (SWP). It has become a means of distributing the State's water resources between the supply areas of the north and the need areas south of the Delta, in concert with Federal and private water development.

Presently, the average annual runoff to the Central Valley floor is about 30 million acre-feet. Diversions, primarily for irrigation, reduce this flow so only approximately 18 million acre-feet reach the Delta. About 1.5 million acre-feet are required for consumption in the Delta and about 12.5 million are estimated to be the future requirement for export from the Delta by the CVP and SWP. Increased requirements for water exported from the Delta and increased need to meet water quality standards contained in export water supply contracts will exceed the supply capability of the present cross-Delta conveyancy about 1980.

Use of the Delta

In its present manmade state, the Delta supports about 570,000 acres of agriculture; about 5 million days of recreational use per year (about 60,000 boats are registered for the area); more than 3.5 million days of fishing per year; an annual ocean commercial salmon catch of about 6 million pounds; a commercial shad catch of almost 1.5 million pounds; and a cross-Delta water transfer of about 2 million acre-feet per year.

In contrast to these benefits, the Delta is faced with a myriad of present and future problems, some of which may be summarized as follows:

1. Maintenance costs of the essentially privately-owned levee systems are steadily mounting due to land area subsidence (about 0.1 foot per year) and wave erosion caused by pleasure and commercial boating in the waterways.
2. Competition from other areas for high-value produce crop markets and for available labor is forcing the Delta to use lower cost, mechanized types of farming.
3. Waste discharge into the waterways from farming operations, municipal waste treatment plants, and ships and recreation boats is creating water pollution problems.
4. Increased commercial shipping is creating a demand to deepen the Stockton and Sacramento Ship Channels which would place added stress on the levee systems and possibly on the marine environment.
5. Increases in export pumping cause problems with anadromous fish spawning and possibly with the fish food supply.
6. CVP and SWP officials are negotiating with Delta interests trying to collect payments to guarantee a year-round supply of quality water to Delta water users.
7. Adoption of water quality standards, while assuring quality water in the wasteways, creates problems in maintaining the fragile levee system and in disposing of wastes from the land areas.
8. Special interest groups compete to have areas of the Delta zoned exclusively for municipal development, for recreational development, for fish and wildlife enhancement, or for maintaining the Delta in its "natural" state.
9. Facilities are needed to accommodate a steadily increasing recreational use of the Delta. (Some natives of the area say there are already too many boats and recreationists in the Delta.)

Solutions to the Problems

Numerous solutions to these problems have been proposed and each has been met by a steady stream of invective rhetoric demanding that the Delta be preserved in its "natural" state. To discuss all motives behind the passionate pleas would fill volumes, however, several facts surrounding the situation are obvious.

The Delta is not in its natural state and has not been for over 100 years. The economic and social impact of returning the Delta to its natural state would be unacceptable to today's generation.

Many of the Delta's plants are hybrid varieties. Its animals are selectively bred and nourished for designated purposes; a large number of its fish

Top, Delta floods have "reclaimed" another section of the levee.
Center, Delta levee failure—a continuing vigilance for these workers.
Bottom, Sandbags have rescued this levee from complete destruction.

and wildlife resource species were imported from other areas and are carefully managed to meet a constantly increasing public demand; its levee systems must be regularly maintained; its land areas are constantly sinking; the flow and quality of waters in its streams are controlled much of each year by the works and actions of man; and increasing population in areas south and west of the Delta is placing greater demands on water supplies north and east of the Delta. The Delta is, therefore, a manmade, managed, or more descriptively, a *contrived and transient* environment.

The only real solution to saving the Delta is to manage it. Since all special interests cannot be satisfied, the best possible alternative would be to manage the Delta for maximum benefit of the greatest number of people.

Solutions Progress

Numerous plans and studies directed toward solving Delta problems are in various stages of progress. Among these are:

1. The proposed joint Federal-State Peripheral Canal would convey export waters around the eastern periphery of the Delta while at various points distributing flow to the interior Delta for consumption. It would remove the impact of cross-Delta water transfer on the Delta fishery.
2. Water quality standards have been adopted for protection of water users in the Delta.
3. Water rights diversion permitting conditions to extend water quality controls to the extreme western Delta and upper Suisun Bay are currently undergoing court tests.
4. Restrictions on municipal and industrial waste discharges, and commercial and pleasure boat discharges are being enforced.
5. Proposals to fill Delta island areas with organic wastes from the Bay area cities and with dredging spills from maintenance of the Stockton and Sacramento Ship Channels are being investigated.
6. Studies of recreational development and of zoning needs for future development of the Delta are being conducted by local, State, and Federal agencies.
7. Future waste disposal needs of the San Francisco Bay-Delta area are being studied.
8. Studies required for future management of the Delta fishery and waterfowl habitat main-

tenance in the Suisun Marsh on the western edge of the Delta are in progress.

9. Studies of need and design of future improvements to the Sacramento and Stockton Ship Channels are in progress.

The Delta has been used for many decades to meet the needs of man. These uses and the ravages of nature have created problems which are of critical importance today. With proper management, based on vastly enlarged data provided by the aforementioned studies and plans, as well as other studies, present and future, the Delta will continue to be a storehouse of benefits for California and for the Nation. # # #

NEWS NOTES

B. P. Bellport Retires

B. P. Bellport, who has headed the Bureau of Reclamation's design and construction activities since 1963, retired March 31, 1972, concluding a 35-year professional career with the Bureau.

Harold G. Arthur, presently deputy director of the Division of Design and Construction, has been designated acting chief of the division.

Reclamation Art Exhibition

A selection of paintings, watercolors and drawings chosen from more than 300 pictures in the Bureau of Reclamation's art program went on view March 25, 1972, at the National Gallery of Art.

Beginning in the fall, "The American Artist and Water Reclamation," as the exhibit is called, will be circulated throughout the country under the auspices of the Smithsonian Institution Traveling Exhibition Service.

A 27-minute color motion picture, dealing with Reclamation's effects on the environment, as seen through the eyes of the artists participating in the art program, premiered in the National Gallery on the opening day of the exhibit.

John DeWitt, developer and director of the Bureau's art program, received the Department of the Interior's Award for Meritorious Service.

Leon W. Hill Retires

Leon W. Hill, director of Region 5 of the Bureau of Reclamation since July 1959, retired April 29, 1972, after more than 36 years of Federal Government service. Region 5 with headquarters in Amarillo, Tex., encompasses all of Texas and Oklahoma, most of New Mexico, and portions of Kansas and Colorado.

James A. Bradley, chief of the Bureau's Division of Power in Washington, D.C., since 1970, succeeded Mr. Hill.

Bradley began his 24-year career with the Bureau in 1948 as an electrical engineer in the South Platte River District office in Estes Park, Colo. He spent 12 years in Region 5 and 2 years in Region 6 before coming to Washington.

Reclamation Assists Minority Contractors

Reclamation joined with the Small Business Administration to award a $47,000 contract to a minority construction firm for work in the Central Valley project in California.

Under the contract awarded, the R. D. Ramirez Construction Co., South San Francisco, Calif., will remove loose rock and boulders from the tailrace channel below Folsom Dam on the American River in the Central Valley project.

New Hoover Dam Facilities

New facilities at famous Hoover Dam have increased the visitor-handling capacity by a third. They were completed ahead of this year's peak tourist season, which began Memorial Day weekend.

The new facilities include an improved access tunnel in the Nevada wall of Black Canyon and a new platform over the lower penstock, deep in the canyon wall, through which water flows to the giant turbines in the Hoover hydroplant.

With the 1972 trek running well ahead of last year's, the 15 millionth visitor will take the guided tour in October while approximately 90 million will have visited the Lake Mead National Recreational area which extends from the head of Lake Mead to Davis Dam, downstream from Hoover Dam. # # #

Answers to Water Quiz

1. d; 2. c; 3. a; 4. These stairs became superfluous upon the completion of Shasta Dam. Prior to its construction, Sacramento River frequently overflowed and flooded the city, requiring the high stairs; 5. b, c, a, d.

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MAJOR RECENT CONTRACT AWARDS

Spec. No.	Project	Award date	Description of work or material	Contractor's name and address	Contract amount
DS-6913	Pick-Sloam Missouri Basin program	May 5	Environmental study, Upper South Platte unit, Mount Evans Division.	International Engineering Co., Inc. San Francisco, Calif.	$200,000
DC-6944	Pick-Sloan Missouri Basin program	May 12	Additions to Stegall substation	Addison Construction Co., Denver, Colo.	192,727
DS-6946	Columbia Basin	Apr. 28	Design of Grand Coulee Visitor Arrival Center.	Marcel Breuer & Associates, New York, N.Y.	165,471
		Contract date			
DR-12-21	Atmospheric Water Resources Management program.	Apr. 20	Comprehensive evaluation of cloud seeding results.	Aeromatic Research, Inc., Goleta, Calif.	239,308
100C-1195	Columbia Basin, Washington	Apr. 4	D85-22, -23A, -24, -31, -82, and -84 drain systems, block 85.	John M. Keltch, Inc., Pasco, Wash.	221,025
100C-1197	do	May 1	Drains and D16-37 pumping plant, block 16, schedules Nos. 1 and 1A.	do	323,640
100C-1203	do	May 23	Buried pipe drains, block 87, schedules Nos. 1 and 1B.	Roy Johnson Construction Co., Inc., Ephrata, Wash.	226,907
400C-498	Colorado River storage project	May 5	Water filtration plant addition, Glen Canyon unit.	E. Arthur Higgins, Centerville, Utah	504,470
604C-88	Pick-Sloan Missouri Basin program, Helena-Great Falls Division.	Apr. 7	Westside dike	Empire Sand & Gravel Co., Inc., Billings, Mont.	367,300
604C-89	Pick-Sloan Missouri Basin program, Three Forks Division.	May 11	Earthwork and structures for pipe drains, berm construction, and modification of channels, fiscal year 1972.	Clark Bros. Contractors, Victor, Mont.	107,647

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